CGMS-XXVII
PRC-WP-07
Prepared by CMA
Agenda Item: H1

Flood Monitoring in China during the Summer Season of 1998 by Using Meteorological Satellite Data

Summary and purpose of paper

This paper provides the information on flood monitoring in China in 1998 by using NOAA/HRPT data. The flood was one of the biggest flood in the history of China.

Flood Monitoring in China during the Summer Season of 1998 by Using Meteorological Satellite Data

Polar orbiting meteorological satellite has such features of large range of coverage, frequently observation plentiful information of detection, thus can be used to monitor the flood in large size efficiently. This paper introduces the general principal and method of data processing and analyzing for flood monitoring by using meteorological satellite data. Also some examples for monitoring the severe flood happened in China during the summer of 1998 are presented.

1. The Principal of Flood Monitoring by using Meteorological Satellite Data

Onboard the NOAA polar-orbiting meteorological satellite AVHRR channel 1 and 2 with the wavelength from 0.58~0.68 μm and 0.725~1.0 μm separately, can detect the reflection to solar radiation from ground and cloud surface. The flood usually happened in crop growing season, and ground surface could be covered by crop in large size. Then, the major target easily discerned from meteorological satellite data are vegetation water body and cloud, and their reflective spectrum characteristics in the wave – length range of AVHRR channel 1 and 2 are quite different.(see Fig.1)

According to Fig.1, the albedo of vegetation in the wavelength of channel 1 is lower than

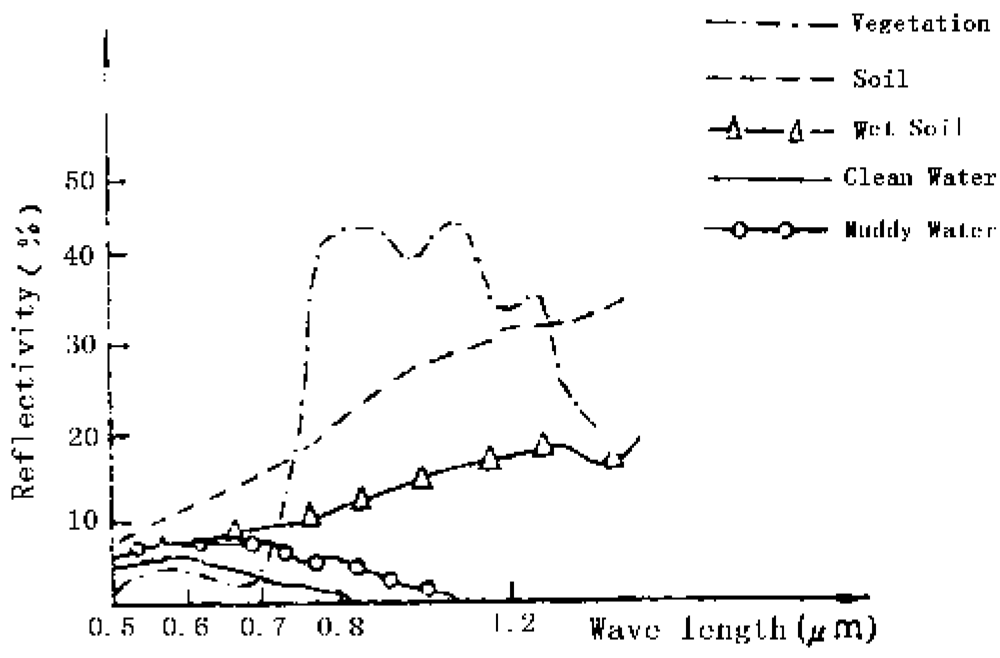

Fig.1 The spectrum reflectivity curve of typical ground target during flood season

that of channel 2, and the albedo of water body in the wavelength of channel 1 is higher than that of channel 2. In the range of wavelength of channel 2, the albedo of vegetation is higher that of water body. In the range of wavelength of channel 1, the albedo of water body is higher than that of vegetation. Thus, during flood period, the reflective spectrum characteristics of water body, vegetation and cloud are much different in the range of wavelength of AVHRR channel 1 and 2, This feature can be used to monitor the water body on ground surface during flood period.

Through the comparison from the images of channel 1 to channel 2, we can see that: on the channel 1 images, the intensity value of water body is higher than that of land around, and the boundary of water body and land is not clear. But on the images of channel 2, the intensity of land (usually represents vegetation) is much higher than that of water body, and the boundary of water body and land is much clear. And also, the intensity of cloud is much higher than that of ground surface.

The range of wavelength of AVHRR channel 4 is in infrared waveband. Channel 4 can be used to detect the temperature on surface of cloud and ground, but the difference of temperature of water body and land in flooded area are usually not distinct. So, generally channel 4 data is not used to detect the flooded water, but it can be used to determine city area.

Meteorological satellite has the advantages of large coverage and quite frequently observation. The swath of AVHRR is 2600km, and the length of pass of single station can be up to 4000 km. Currently, there are two NOAA polar-orbiting meteorological satellite in operational mode, that means, every place on ground can be observed by polar orbiting meteorological satellite every 6 hours. This is very useful for monitoring flood in large scale.

2. The Method of Data Processing in Flood Monitoring by Using Meteorological Satellite

2.1 Color Image of Multiple Channel Composition

To derive the information of water body from AVHRR data, the color images of multiple channel composition are needed to be generated first for discerning manually water body , vegetation and cloud in the image. According to the spectrum characteristics of ground target and cloud in the range of wavelength of AVHRR channel 1,2 and 4,the blue, green and red colors are assigned to channel 1, 2 and 4 respectively. In this three channel composition image, blue (or dark), green, white and dark red color are represent water body, vegetation (including crop), cloud and city information respectively. The raw data of channel 1 and 2 images are hard to discern water body and land. Using step enhancement, the contrast of different ground target can be greatly increased, thus water body and land can be distinguished clearly.

2.2 Discerning Water body

The key step of flood monitoring using meteorological satellite data is discerning water body. The resolution of AVHRR sub-point is about 1 km^2, and when big flood happened, the flooded size often up to hundreds even thousands of km^2, which influence many pixels on an image. To determine the range and size of flooded area, computer is needed to be used to scan every pixel in the area. According to the characteristics of channel 2 in the boundary of water body and land, the threshold of albedo for discerning water body can be determined interactively, then using the threshold program will scan the data in the area. The data higher than the threshold will be considered as land, other wise, the water body will be considered.

Generally, using the method above to monitor flood is efficient, but in some cases it has problems, and then some special steps need be used:

(1) When flooded area is in large scale, using single threshold to scan a whole image often caused the water body discerning incorrectly. Because in large area, the ground features, such as vegetation coverage and crop growth, may much different. A threshold may be suitable for one area, but may not be suitable for other area quite far away from it. To reduce the errors in discerning water body, different thresholds should be considered for the areas which have much difference on ground surface.

(2) When flooded area is covered by thick cloud, no information from ground surface can be seen in channel 1 and channel 2 images. But when cloud is quite thin, a part of reflection from ground surface can transmit through the cloud, then the ground surface under thin cloud can be seen in the images of channel 1 and channel 2. Although the boundary of water body and land is not as clear as cloud free condition, but it still can be discerned. Because the water body is covered by thin cloud, the albedo of the data may be higher than the land around. In this case, if only channel 2 data is used for threshold, the land around the water body covered by thin cloud may be discerned as water body. To avoid this kind of mistake, the method of radio calculation between channel 1 and channel 2 can be used to delete this influence as the transmissivity of vegetation and water body in the range of wavelength in channel 1 and channel 2 is same. The result of channel 2 data divided by channel 1 can delete the influence of thin cloud efficiently.

2.3 The Size Calculation

2.4 The size calculating for flooded area is to derive the sum total of the size for every pixel in the flooded area. There are many ways for the calculation, here we do not discuss in detail.

2.5 Determine the Range and Position of Flooded Area

As the resolution of meteorological satellite data is quite low, it is difficult to determine whether the water body is in flooding just from a single image. The part of water body changed can be distinguished by comparing the images received in different date. Using the water body received during flood to compare with the one before flood, the expansion part is usually the flooding area. Using the water body received after flood to compare with the one during the flood, the shrinking part is usually the receded range of flood. By using GIS, we can determine the geographic range and administrative area stricken by flooding, evaluate the size and percentage of flooding in certain county, which can provide the information for evaluating economic loss.

2.6 Evaluating the Loss of Crop Stricken

Using a duration of flooding staying in certain area as a standard to determine whether the crop died of immersing for a long period, we can monitor the flooded area continuously and evaluate the size of reduction or die out of crop. Using anomaly vegetation index, the range and size of stricken crop caused by flooding are also can be evaluated. That means, using the NDVI derived from the day during the flooding compared with the average of NDVI from the data in multiple years, the growth of vegetation can be shown. The NDVI will be lower when crop is died of flooding, then the value of anomaly NDVI will be minus, and thus the level of crop stricken will be reflected.

3. The Operational Procedure of Flood Monitoring

When flood season comes every year the condition of water body in the basin of seven major rivers where flood happened quite often in China should be monitored in daily operation. The water body information are derived every day to establish the data set of background of water body to be used for comparing the one when flood happened. The procedure of flood monitoring is as following:

(1) Real-time data receiving.

(2) Data preprocessing

(3) Playback the whole pass data select the portion to be monitored.

(4) Step-enhancement is used for AVHRR channel 1 , 2 and 4 to generate three channels composition color image.

(5) Earth location correction.

(6) The threshold of water body are selected interactively and automatic discerning are carried out.

(7) Check if the threshold is correct, if not, return to step 6.

(8) Administrative boundary is overlaid and the size of flooding in each county is calculated.

(9) Generate a special image for water body monitoring, on which the different color means different information, i.e. blue for background water body, red for expanded water body comparing to background, yellow for shrunk water body, green for vegetation, and white for cloud.

4. Flood Monitoring in 1998 by NSMC/CMA

NSMC/CMA started to use meteorological satellite data monitoring flood since middle of 1980's, and used to monitor the several severe flood successfully, like flood happened in Yangtze River in 1991, in North China in 1996 , etc. During the summer of 1998, the severe flood happened in the basin of Yangtze River and Nenjiang River. NSMC used NOAA data to monitor this flood and provide much information about the flood to the related government department. From the early of May, NSMC monitored the water body condition of the basin of seven major rivers twice each day. In the whole summer season, 302 cloud free images in the area to be monitored are derived, including the severe flooded area, such as 33 images for the region of Dongting Lake, 39 images for the region of Boyang Lake, 17 images for the region of Nenjiang River. When the severe flood happened in Yangtze River and Neijiang River, every day NSMC did the data processing and analyzing for the flooded area, generated the flood monitoring images to show the range of flooding according to the procedure explained above, and transferred the images by remote communication to the related government departments in the current day. These images showed the changing of water body range vivid for most part of severe flooded area. This time, the features of large coverage of NOAA AVHRR played an important role . In some day, we can get the images covered all flooded area within two hours, including Nenjiang River which is in the Northeast Part of China, Yangtze River which is in the South of China. In some days, we can get cloud free images for certain severe flooded area each day continuously. These images with large coverage and frequently observation provided much important information to related government departments for knowing the situation about flooding in the range of whole country. The following are part of these images from NOAA AVHRR which briefly introduce the monitoring to the flood in China in 1998:

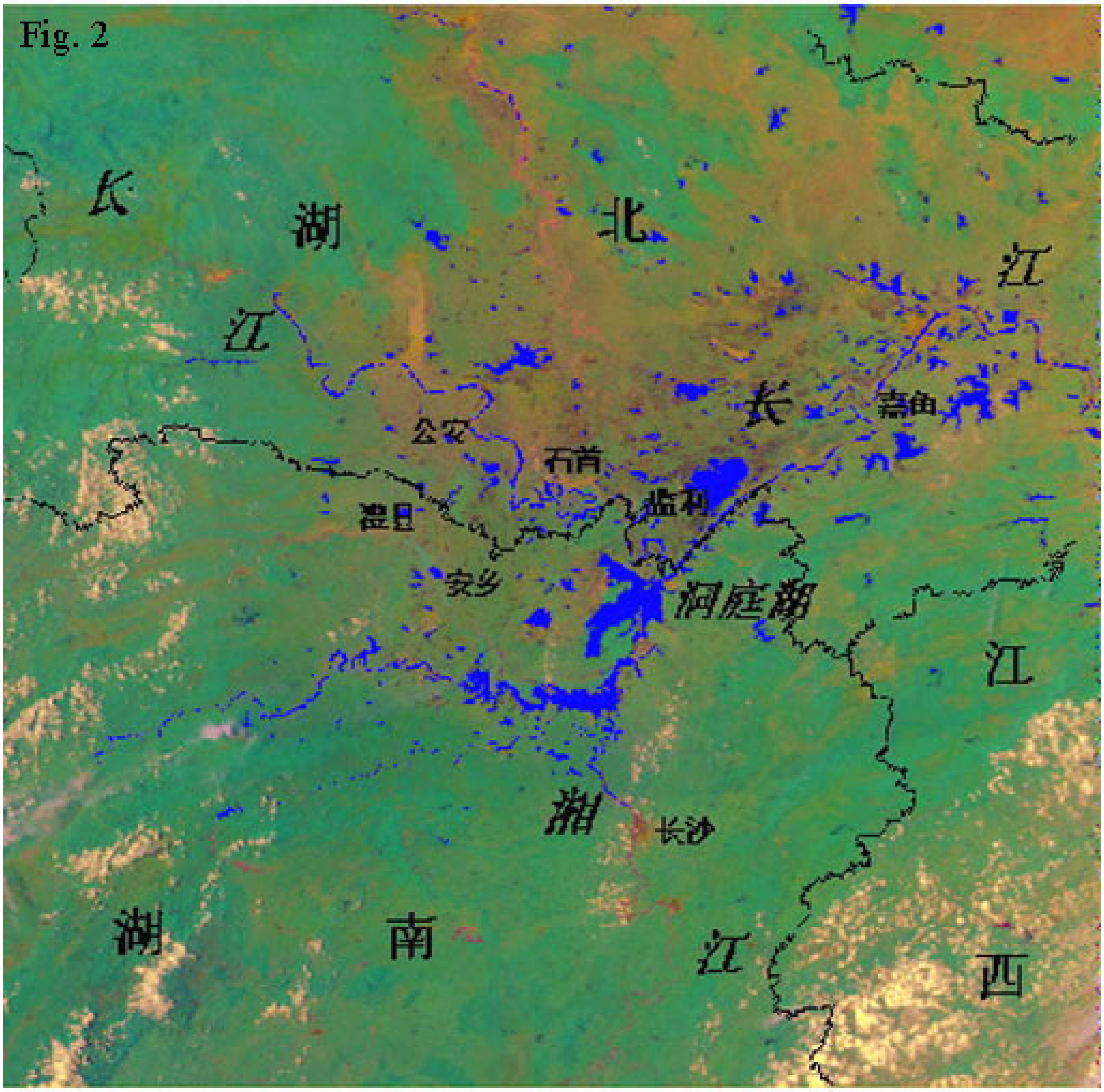

Fig. 2

Fig. 2 : The image received in May 25, 1998 (before the flood) which covers the Dongting Lake where is in the basin of Yangtze River. The image shows that Yangtze River is only a single line appeared on the image.

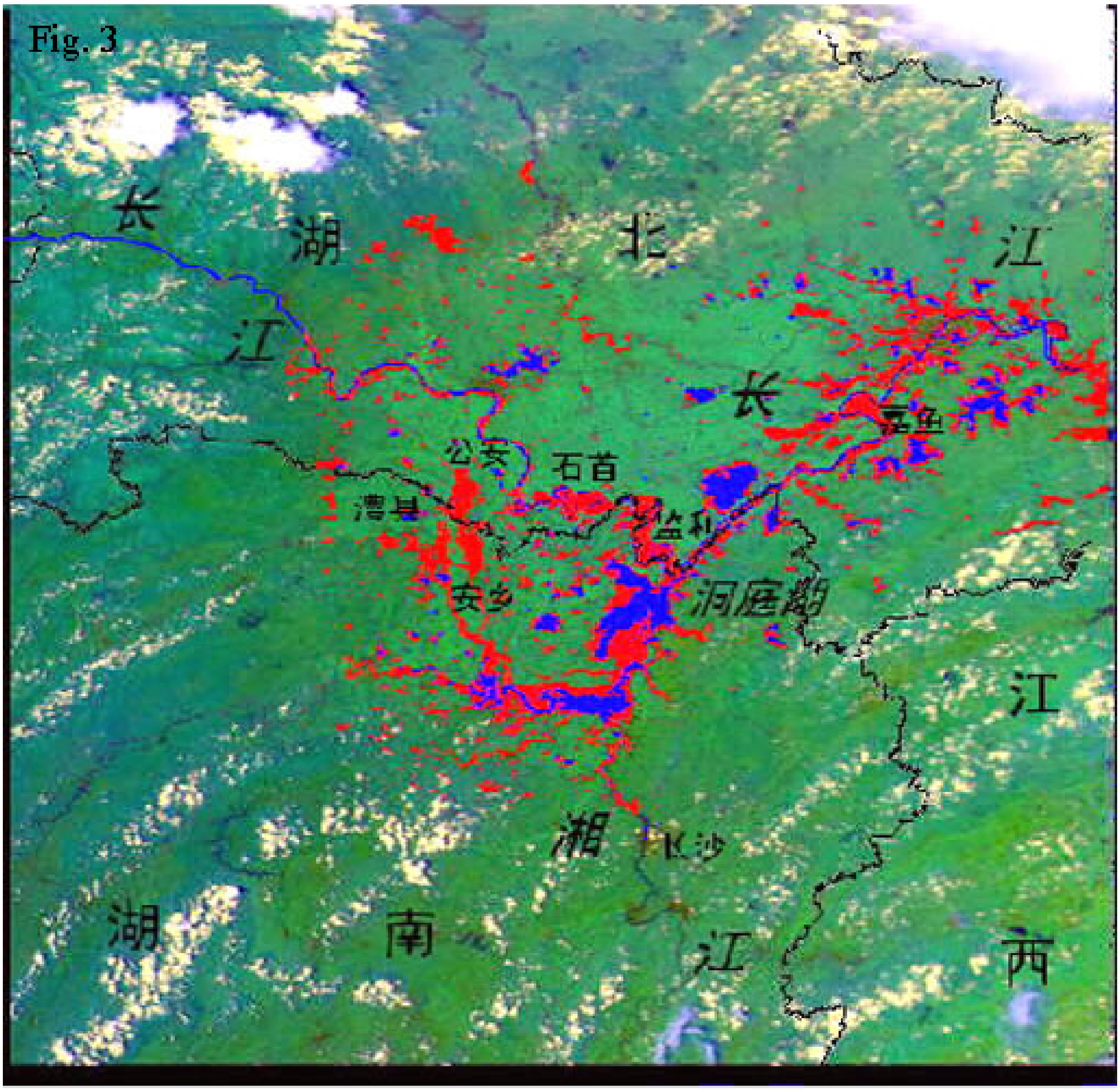

Fig. 3: The image received in August 23, 1998 (during the flood) which covers same area as Fig. 2. The red color represents the flooded water body. Comparing to Fig. 2, we can see Yangtze River expanded widely in some area. Besides, there are some large flooded water body appeared in Hunan and Hubei Provinces.

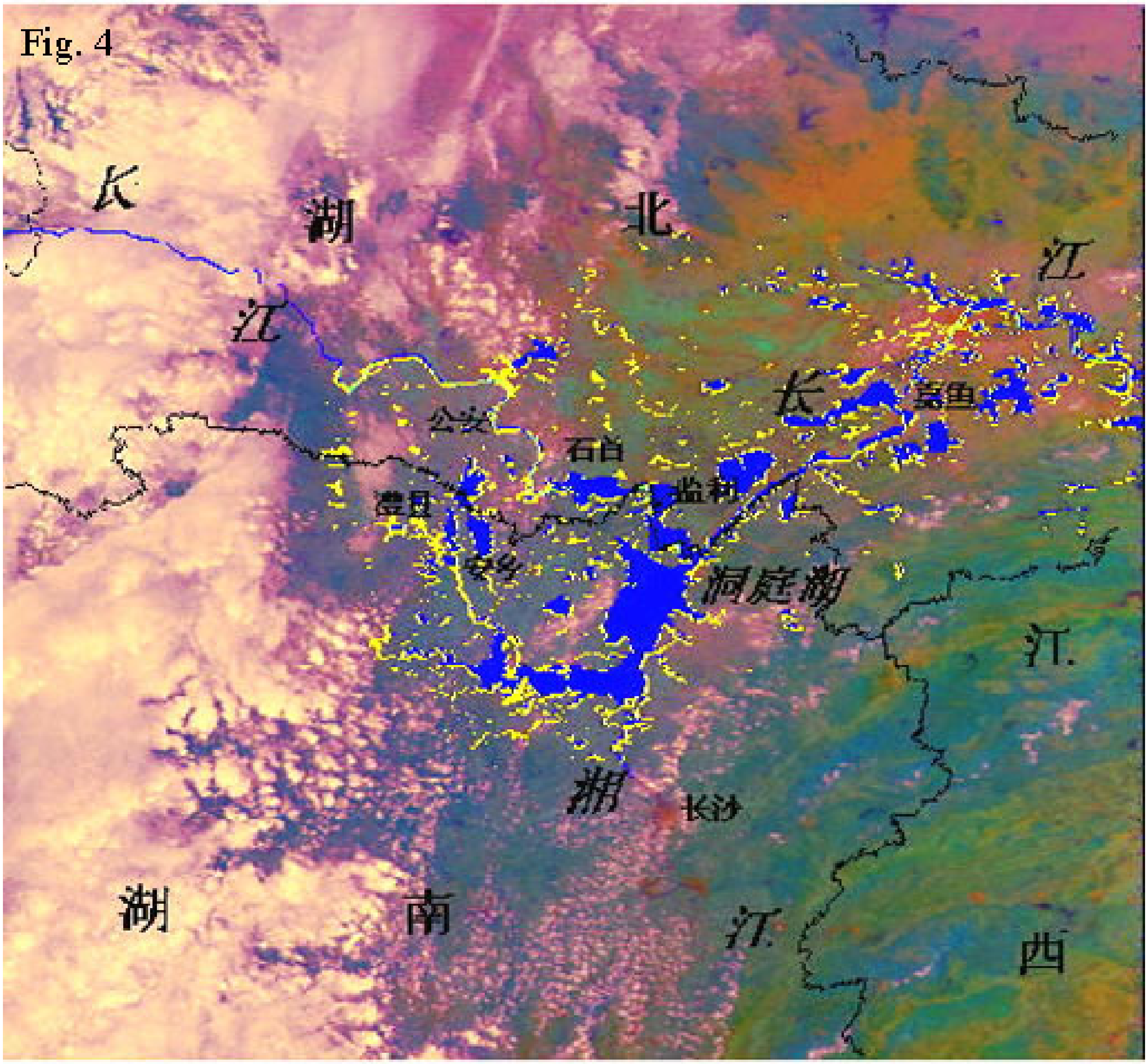

Fig. 4 : The image received in September 10, 1998 (after the flood) which covers same area as Fig. 3. The yellow color represents the reduced water body range compared with Fig. 3, which shows that flooded water body has been shrunk.

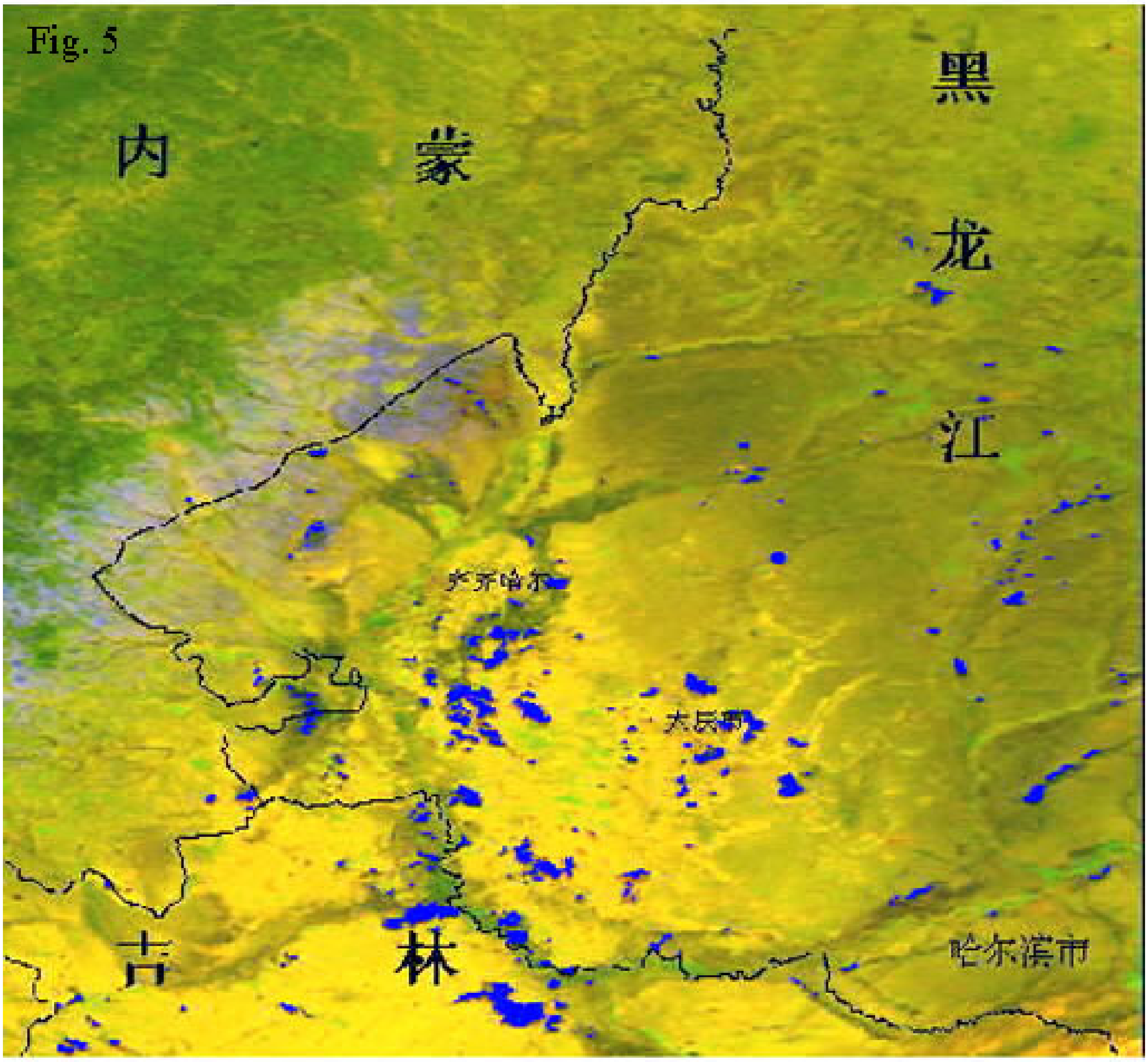

Fig. 5 : The image received in May 2, 1998 (before the flood) which covers the basin of Nenjiang River. From the image, we only can see some lakes. The Nenjiang River is so narrow we even can not see it.

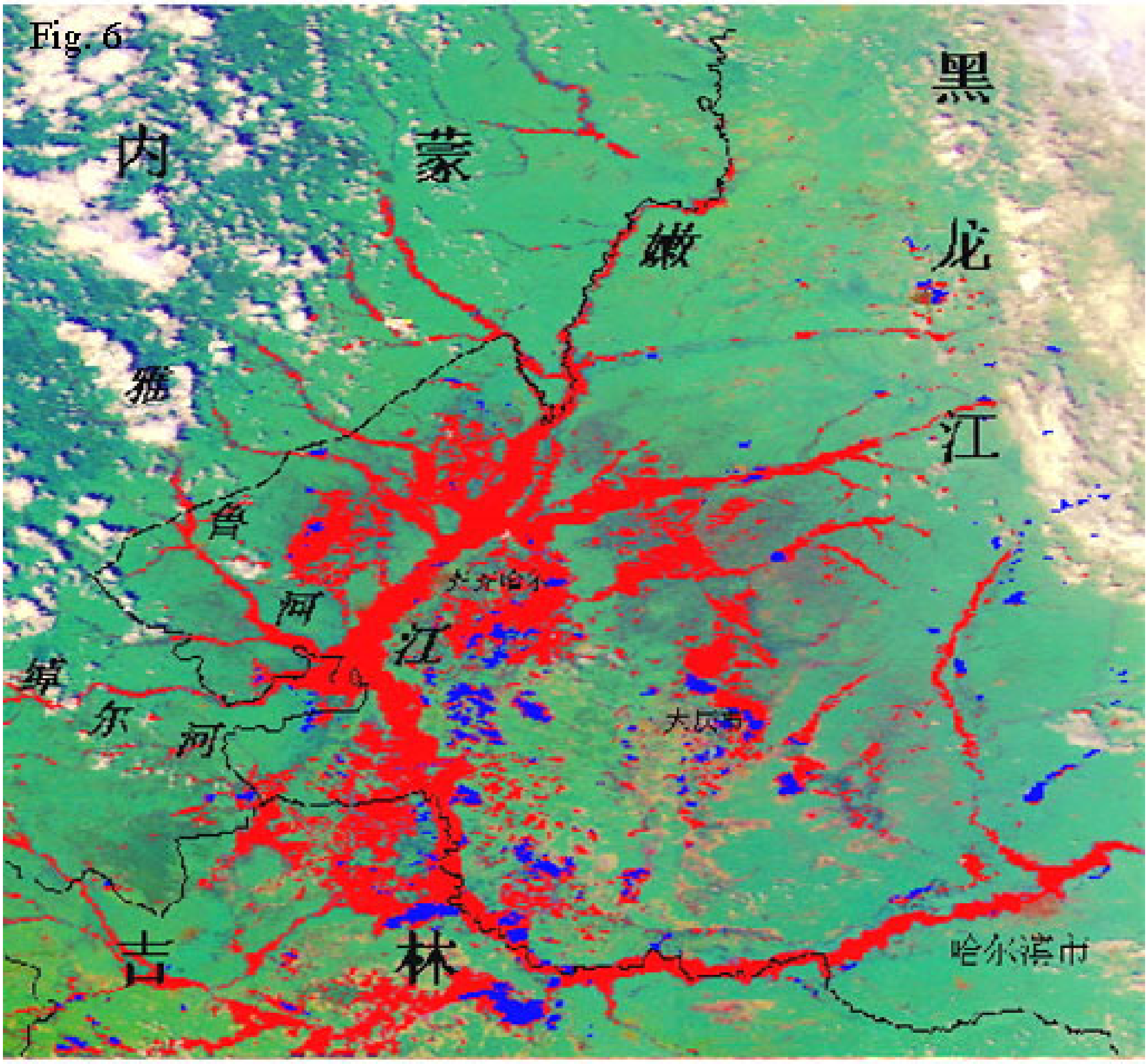

Fig. 6 : The image received in August 23, 1998 (during the flood) which covers the same area as Fig. 5. The red color represents expanded water body compared with Fig. 5, which shows that some area got severe flooded.

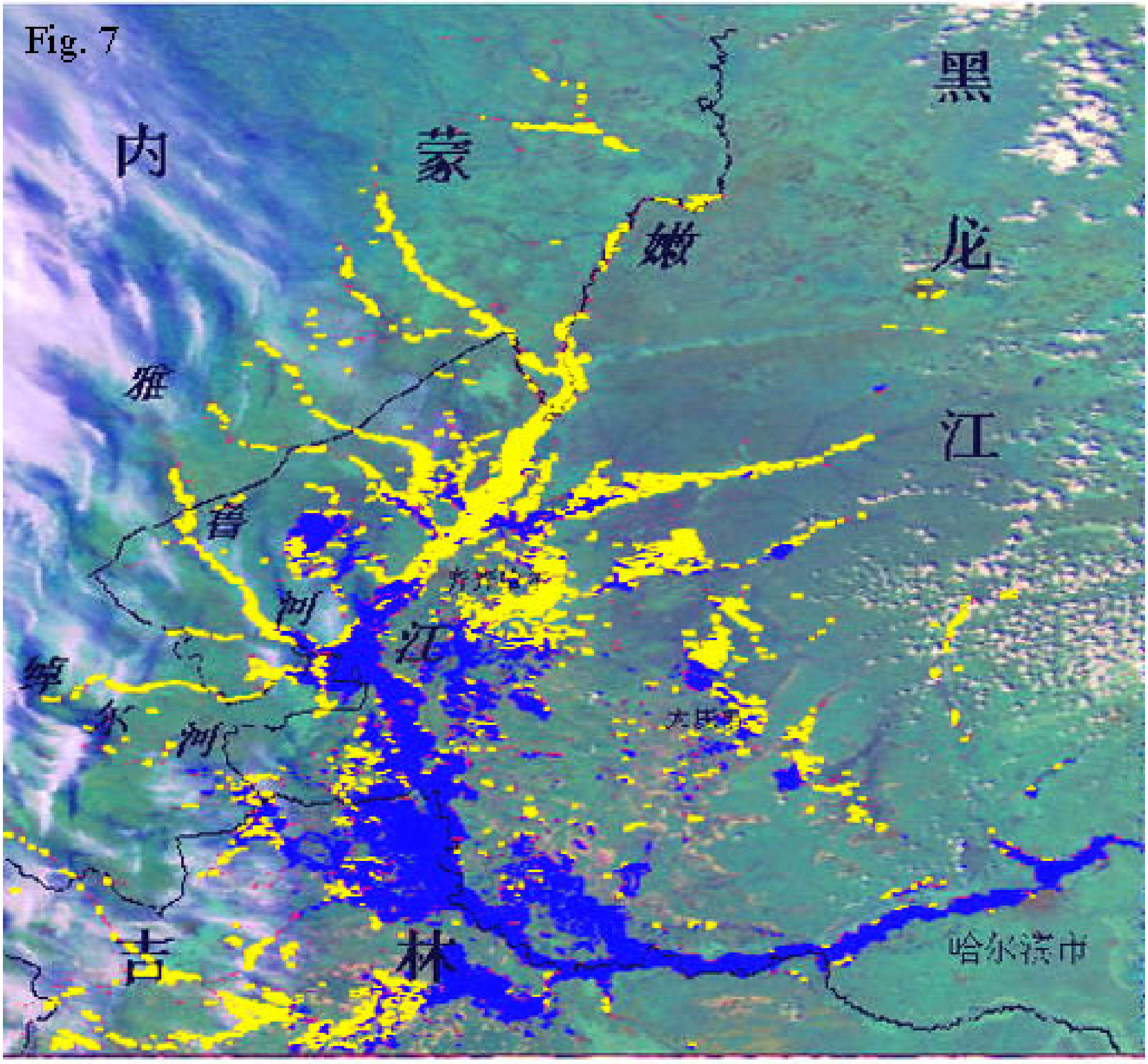

Fig. 7 : The image received in September 16, 1998 (after the flood) which covers the same area as Fig. 6. The yellow color represents the reduced water body range compared with Fig. 6, which shows that the flooded water body range has been shrunk in some area.